# Detection of Faults in AC to AC Converter Fed Induction Motor Driver

Vivek Sharma
Assistant Professor
mail.vivek21@gmail.com

Gaurav Mendiratta
Research Scholar
gauravmendiratta92@gmail.com

Department of Electrical &Electronics Engineering, Graphic Era University

**Abstract**- This paper presents simulation results of the harmonics analysis of motor current signatures under different fault condition of CSI (Current Source Inverter) fed induction motor drive. In this work, simulation studies are performed for two different post fault conditions i.e. open circuiting of one of the six IGBTs(Insulated Gate Bipolar Transistor) gate, blowing off one IGBT .Under these fault conditions, time domain and frequency domain analyses are performed. The simulation results are presented.

**Index Terms**-Induction Motor, FFT Spectrum, THD, Faults at IGBT

## I. INTRODUCTION

Induction Motor for many years has been regarded as workhouse in industrial applications. In the last few decades induction motor has evolved from being a constant speed motor to variable speed, variable torque machine. When the application requires large power and torque specifications, the usage of induction motor comes into demand. This results in application of an efficient machine which is stable during various fault conditions.

Hence machine fault detection becomes an important factor of concern. In past decades a number of different incipient fault detection methods and schemes have been presented.A Review of Induction Motors Signature Analysis as a Medium for Faults Detection (Benbouzid M.E.H) deals with a concise manner the fundamental theory, main results, and practical applications of motor signature analysis for the detection and the localization of abnormal electrical and mechanical conditions that indicate, or may lead to, a failure of induction motors [1].Current Harmonics Analysis of Inverter-Fed Induction Motor Drive System under Fault Conditions (*Biswas* B.) deals with harmonic analysis of motor current signatures under different fault conditions of medium and high power Variable Frequency Drive (VFD) systems. Computer simulation of a VSI fed induction motor based on constant voltage/frequency (V/f) operation is implemented using Powersim (PSIM) simulation software [2]. Simple Stator Fault Detector for AC Motors (Bin Huo) proposes a simple stator fault detector for ac motors, based on the TMC320C243 DSP controller is presented. The detector provides compensation of the constructional and supply voltage imbalances, and senses the ripple of the compensated instantaneous power [3].Load-Commutated SCR Current-Source-Inverter-Fed Induction Motor Drive With Sinusoidal Motor Voltage and Current (Debmalya Banerjee) proposes a CSI-fed induction motor drive scheme where GTOs are replaced by thyristors in the CSI without any external circuit to assist the turning off of the thyristors [4].Voltage Stresses on Stator Windings of Induction Motors Driven by IGBT PWM Inverters(Don-Ha Hwang) describes the distribution characteristics of switching the surge voltage in the stator windings of an induction motor driven by IGBT PWM inverter[5].Online Diagnosis of Induction Motors Using MCSA(Jee-Hoon Jung) presents an online induction motor diagnosis system using motor current signature analysis (MCSA) with advanced signal-and-data-processing algorithms is proposed. MCSA is a method for motor diagnosis with stator-current signals [6].Motor Current Signature Analysis and Fuzzy Logic Applied to the Diagnosis of Short-Circuit Faults in Induction Motors (Luís Alberto Pereira) presents the development and the practical implementation of a system for detection and diagnosis of interturn short-circuits in the stator windings of induction motors. [7]. Modeling And Simulation of the Three-Phase Induction Motor Using Simulink (Shi K. L.) describes a generalized model of the three-phase induction motor and its computer simulation using MATLAB/SIMULINK. Constructional details of various

sub-models for the induction motor are given and their implementation in SIMULINK is outlined [8].The above literature does not deal with simulation of faults in the 3-phase converter/inverter fed Induction Motor drive. This work deals with the faults in rectifier and inverter circuits.

## 2. CSI-FED INDUCTION MOTOR DRIVE

An inverter, in which the input current is maintained constant, is called as Current fed inverter. In current source inverter the input behaves as a current source. This can be incorporated by connecting an inductive load in series with the voltage source. The output voltage only is forced to change. The current flows through the inductor to the inverter module. In current source inverter power lows from a large inductor to the inverter section. The "Insulated Gate Bipolar Transistor" (IGBT) is a common choice in modern CSIs and VSIs. The IGBT can switch on and off several thousand times per second and precisely control the power delivered to the motor. The IGBT uses "pulse width modulation" (PWM) technique to supply a sine wave current at the desired frequency to the motor. CSI- fed drive provides controlled input DC current, hence problem of short-circuit and misfiring of switching devices would not be serious problems. Commutation circuits are simpler. It has enhanced ability to handle reactive or regenerative load without freewheeling diodes.

In industrial complexes, many induction motors, may often be running at no load or partial load. Irrespective of the load condition, these loads are however, always connected to the mains. Hence, Proper fault analysis is needed to obtain an efficient machine. This work is mainly concerned for harmonic analysis of motor current signatures for the following types of faults: open circuiting of one of the six IGBTs gate signal, blowing off one IGBT.The faults are being introduced both inverter module of the CSI fed induction motor drive.

## 3. SIMULATION RESULTS

### 3.1. Without Fault

Circuit for the Detection of faults for three phase induction motor is simulated by using MATLAB. The Simulink circuit is shown in Fig.1. The 415V AC voltage is applied to the induction motor.

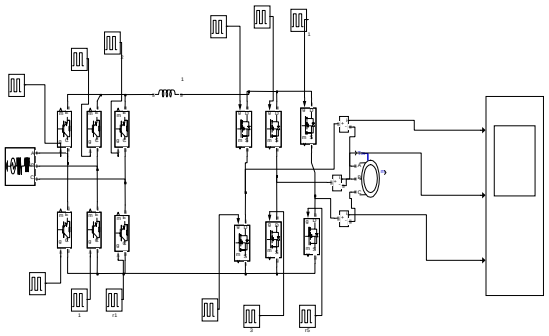

Fig.1. Simulink model for CSI-fed induction motor drive

The waveforms of Line Current Vs Time of the three phases A, B & C respectively under the fault conditions are shown in Fig.2. It is observed that under healthy condition, the current magnitude is 5A.

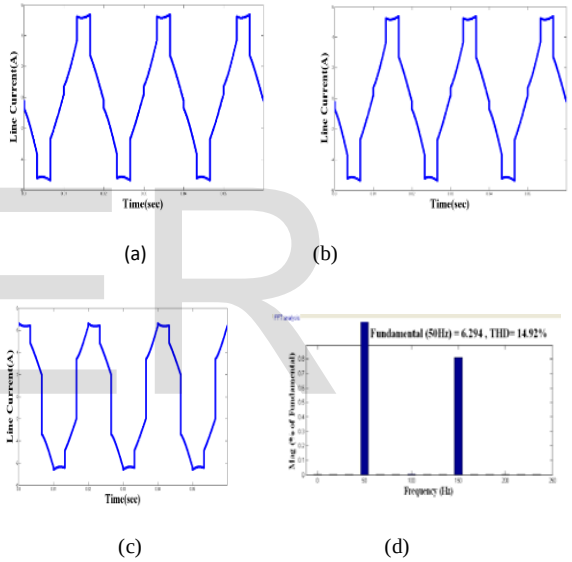


Fig.2. Line Current Waveforms & Line Spectrum under healthy condition
Line current waveform of
(a) Phase A (b) Phase B (c) phase C
(d)Line spectrum under healthy condition

The Line spectrum under the healthy condition is shown in Fig. 2.It shows THD value is 14.92%.

### 3.2. Fault Analysis in Inverter

In this section various faults are introduced in the inverter of the CSI-fed drive.

#### i).Open circuiting of one of the six IGBTs gate terminal

In this case the upper leg Ph A IGBT is grounded in the inverter module i.e. the pulse generator input to the IGBT is absent. The Simulink circuit for this fault condition is shown in Fig. 3.

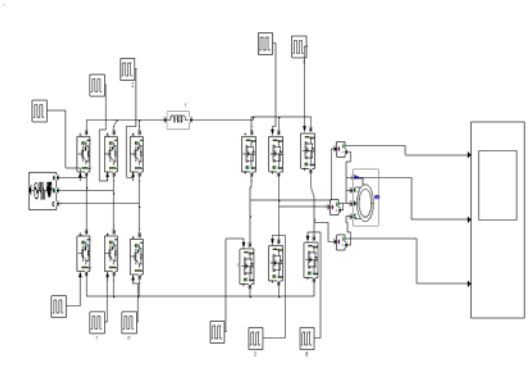

Fig.3.Simulink model with Ph A IGBT open circuited in inverter

The waveforms of Line Current Vs Time of the three phases A, B & C respectively under the fault conditions are shown in Fig 4. It is observed that the current in Ph A gets reversed. The current magnitude is 6A. The Phase B&C current waveforms are also distorted on introducing fault.

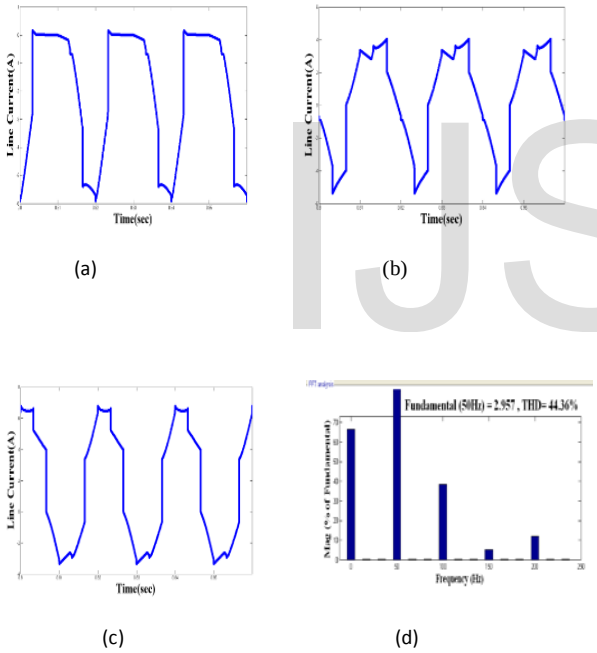


Fig.4. Line Current Waveforms & Line Spectrum with Ph A IGBT open circuited in inverter
Line current waveform of
(a) Phase A (b) Phase B (c) Phase C
(d)Line spectrum with Ph A IGBT open circuited in inverter

The Line spectrum with Ph A IGBT open circuited in inverter is shown in Fig. 4. It shows THD increases by 3 times. The THD value is 44.36%.

### ii). Blowing off one IGBT in the inverter module

To simulate this condition, the upper IGBT in the phase A has been replaced by a high resistance of 1Mega Ohms. The Simulink circuit is shown in Fig.5.

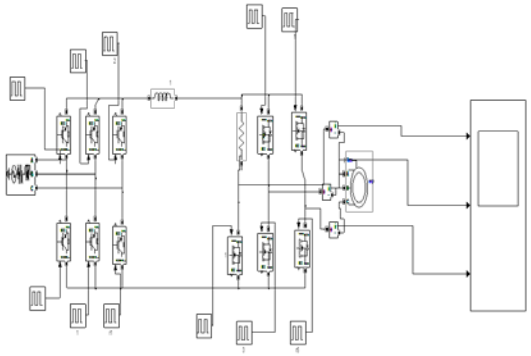

Fig. 5 Simulink model with Ph A IGBT blown off in inverter

The waveforms of Line Current Vs Time of the three phases A, B & C respectively under the fault conditions are shown in Fig.6. It is observed that direction of current waveform of Phase A gets reversed .The magnitude of current is 5A. The Phase B&C waveforms are also distorted on introducing fault.

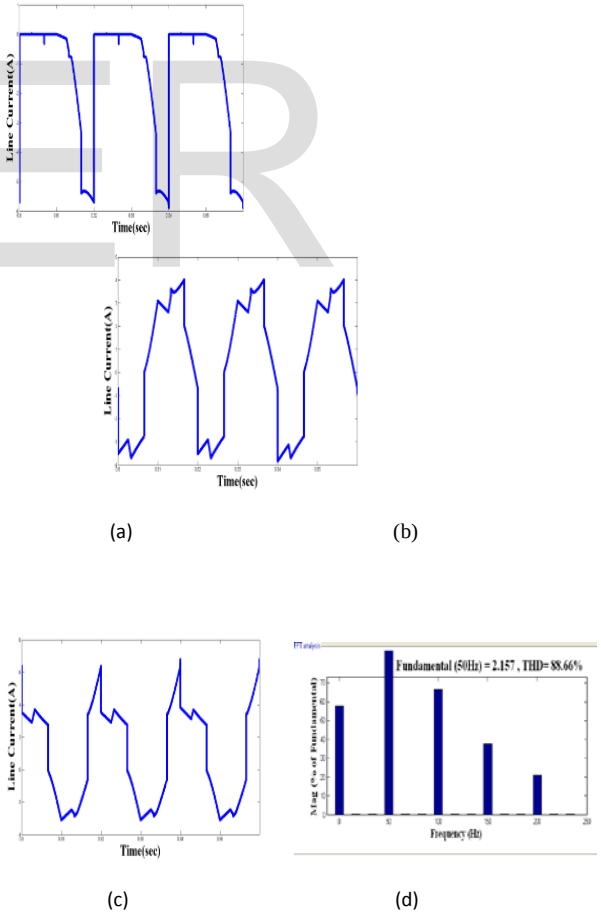


Fig.6. Line Current Waveforms & Line Spectrum with Ph A IGBT blown off in inverter
Line current waveform of

(a) Phase A (b) Phase B (c) Phase C
(d)Line spectrum with Ph A IGBT blown off in inverter

The Line spectrum with Ph A IGBT open circuited in inverter is shown in Fig. 6. The THD increases by 6times. The THD value is 88.66%.

The Summary of FFT analysis of CSI-fed Induction motor drive is shown in Table I. It can be observed that in inverter module, THD due to Ph A IGBT Grounded fault increases by 3 times and due to Ph A IGBT blown off fault, it increases by 6 times. When faults are introduced, the magnitude of current increases for inverter module.

TABLE I. SUMMARY OF FFT ANALYSIS

| CONDITION | THD (%) | CURRENT(Ampere) |
|---|---|---|
| ***INVERTER MODULE*** | | |
| 1. Without Fault | 14.92 | 5 |
| 2.Phase A IGBT Open-Circuited | 44.36 | 6 |
| 3.Phase A IGBT Blown off | 88.66 | 5.5 |

## 4.. CONCLUSION

In this paper, the THDs of CSI–fed drives are evaluated under various fault conditions of inverter circuits. Output waveforms are obtained and THD values are tabulated. From the simulation, it is seen that the current harmonics gets introduced due to introduction of faults in inverter and rectifier module.. The magnitude of current increases for inverter. Frequency responses with FFT spectrum under two different fault conditions are distinctly different which are precisely presented in this paper.

In this paper, induction motor drive system is simulated using CSI –fed drive. There is a scope of simulating the induction motor drive fed form ZSI and 3 Phase AC Chopper circuits.

## REFERENCES

[1] Benbouzid M.E.H (2000), 'A Review of Induction Motors Signature Analysis as a Medium for Faults Detection,' IEEE Trans. Industrial Electronics, vol. 47, no. 5, pp. 984 – 993.

[2] Biswa B.,Das S(2009),'Current Harmonics Analysis of Inverter-Fed Induction Motor Drive System under Fault Conditions,' in Proc. of the International MultiConference of Engineers and Computer.

[3] Bin Huo and Andrzej M. Trzynadlowski(2001), 'Simple Stator Fault Detector for AC Motors, IEEE Trans. Industry Applications,, vol.39, pp. 192-194.

[4] Debmalya Banerjee, Ranganathan V. T.(2009),' Load-Commutated SCR Current-Source-Inverter-Fed Induction Motor Drive With Sinusoidal Motor Voltage and Current' IEEE Transactions on Power Electronics, vol. 24, no. 4.

[5] Don.–H. Hwang, K.–C.Lee, Y. –J. Kim (2003), "Voltage stresses on stator windings of induction motors driven by IGBT PWM inverters', in Proc. 38th IAS Annual conference, vol. 1, pp. 439 – 444.

[6] Jee-H Jung, Lee J, and Kwon B (2006), "Online Diagnosis of Induction Motors Using MCSA", IEEE Trans. Industrial Electronics, vol. 53, no. 6, pp. 1842 – 1852.

[7] Pereira L. A., Silva Gaz G. da zana, and Pereira L.F (2005), "Motor current signature analysis and fuzzy logic applied to the diagnosis of short-circuit faults in induction motors", in Proc. 32nd Annual Conference of IEEE Industrial Electronics Society IECON 2005, pp. 6.

[8] Shi K.L.,Chan T.F. and Wong Y.K.(1999),' Modelling And Simulation Of The Three-Phase Induction Motor Using Simulink', in Proc. Int. J. Elect. Enging. Educ., Vol. 36, pp. 163–172. Manchester U.P.

Vivek Sharma received his M.E. degree in Electrical and Electronics Engineering from Anna University, Chennai, India in 2011. He is presently working as Assistant professor in Electrical and Electronics department, Graphic Era university.dehradun.. His research interest includes fault analysis of squirrel cage induction motors.

Gaurav Mendiratta is a research scholar in EE department of graphic era university Dehradun. His area of research includes power electronics and drives.